WOW Company s.a.
rue Pieds d'Alouette 18 - Parc Industriel
B - 5100 NANINNÉ (Belgium)
☎ + 32 81 40 19 66 • Fax : + 32 81 40 24 44
E-mail : wow.company@skynet.be
R.C. Namur : 50664 • T.V.A. : BE 425.062.314

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True translation of :

« Système pour créer des vagues ou un mouvement à la surface d'un liquide »

« System for creating waves or movement of the surface of a liquid »

no problem!

WOW Company S.A.
c/o Mr. Jean-Baptiste FALLON
rue Pieds d'Alouette 18
5100 NANNINE
BELGIUM

Deinze, 21 February 2004

Dear Mr Jean-Baptiste Fallon

We hereby confirm that this is a true translation of the original.
All pages are initialed.

Yours truly,

JESSICA DOBBELAERE
SWORN TRANSLATOR
COURT OF GHENT
NE VARIETUR

Ms. Jessica Dobbelaere
Managing director *No Problem!*
and sworn translator to the Court of First Instance of Ghent, Belgium.

VAT BE 586 986 887
HR Gent 182.900
Fortis (Belgium) 290-0507075-77
ABN-AMRO (NL) 62.78.52.564
CA (FR) 16706-00180-13342266000-89

Our Ghent Office:
Franklin Rooseveltlaan 348
B-9000 Ghent
Our Deinze Office:
Georges Martensstraat 25
B-9800 Deinze

Contact us:
Tel +32 (0) 9 245 17 89
Fax +32 (0) 9 256 43 50
info@no-problem.info
www.no-problem.info
www.textes-traductions.com

System for creating waves or movement of the surface of a liquid

Field of Invention

The present invention relates to a system for creating waves or movement on the surface of a liquid contained in a pool.

State of the art

A number of wave-making systems have already been proposed.

Thus, it has been proposed that the side wall of a swimming pool or its bottom be fitted with a pipe attached to a piston such that, as water is sucked through one end of the pipe, water exits at the other end into the pool. The creation of movement requires a considerable quantity of water to be impelled and expelled.

There have also been proposals for objects that are to move in a vertical plane above the surface of the pool. Such mechanisms have the disadvantage of being too visible and do not provide optimal functionality.

It is also known that there are baths equipped with jet streams that provide large volumes of water, in which the water output is substantially horizontal. The jet may or may not be controlled according to the state of the surface of an area of the bath.

Finally, there is also a floating ball (WOW ® as marketed by the applicant) capable of creating waves on the surface of the water in a swimming pool. Such a ball provides excellent amplification of wave movement, this amplification being progressive. Such a floating ball does however reduce the usable surface of the pool, both by its volume and by its location (in the middle of the pool, or at least, away from its edges.) Such a ball can be fairly heavy.

The present invention relates to a simple system that allows the creation and control of movement at the water's surface; the said system offers one or more of the following advantages:

- system can be placed in parts of the pool not used for swimming
- easily installed in an existing pool
- better movement or turbulence of the water along the pool walls,
- system is not visible
- possibility of creating massage areas in a section of the pool
- very safe system from the point of view of swimmers' safety.
- etc.

General description of the Invention

This is a system designed to create waves or movement at the surface of a liquid contained in a pool of average level. The system comprises:

- one or more means of acting upon the liquid, chosen from amongst injectors and explicit vortices; preferably several means of action chosen from injectors and explicit vortices, preferably situated and directed in areas and in directions where their effect is optimal.
- one or more pipe to link one or more means of action to one or more source of a fluid under a higher pressure superior than that exercised by the liquid on one or more of the means of action under consideration,
- a device to control the speed and/or the fluid pressure of the fluid output from one or more means of action, or a mobile directional system for one or more of these means of action, or a mask system, or mobile directional flow system for one or more of the means of action.

in which the said means of action are chosen from a group comprising:

- means of action directing, at least in an intermittent fashion, the fluid in the liquid according to a principal direction or in a direction within a cone (in

either 2 or 3 dimensions) forming an angle between -30° and 30°, for example from +15° to -15°, preferably between –10° and +10°, and ideally between –5° and +5°, or even less, in relation to a vertical or horizontal axis.

- means of action directing, at least in an intermittent manner, the fluid along and/or against a wall submerged in the liquid.
- means of action or injectors, directing, in an intermittent manner, the fluid to move in the direction of movement of an action zone [we understand 'action zone' to mean the area in which, by its own movement, the injection causes or amplifies the movement of a mass of water or liquid in the pool, in such a manner that the overall speed of the fluid at the site of action or in the action zone is higher than the natural speed of the liquid if this action had not occurred. In particular the overall speed of the fluid at the site of action will be more than twice the speed of the fluid at the injector output, preferably more than 5 times the speed of the fluid at the injector output, and ideally 10 times the speed of fluid at the injector output, for example between 20 and 50 times the speed of fluid at the injector output, the important issue being that fluid speed in the action zone be superior to its speed in the absence of injectors] of one or more means of action or injectors or crossing an action zone of one or more means of action or other injectors, and
- with a combination of these,

and in which the control device contains a means which adapts the speed and/or pressure and/or the direction of the fluid output from one or more means of action or injectors, in relation to the surface state of a part of the liquid surface, this surface state being preferably detected by a means of detection.

The system comprises one or more, even at least four, preferably at least ten, ideally at least 20 means of action, namely injectors. The number of means of action, namely injectors, depends on the shape of the pool, the volume of the pool, the wave types, the time taken for the waves to achieve a specific height, etc. The larger the number and greater the power of the means of action, namely injectors, the more precisely the waves formed on the surface of the pool can be regulated. The total

number of means of action, namely injectors, may for example be 30, 40, 50, 75, 100, 150, 200, or perhaps even more; these small means of action, namely injectors, being ideally assembled into groups of more than 3 means of action or injectors for example between 5 and 30 means of action or injectors each group of means of action or injectors acting in an area of the pool or having an action zone within an area of the pool, in particular in an area of the pool adjacent to a side wall of the pool.

Preferably each means of action or injector will be adapted to achieve a fluid speed at the output of each means of action or injector (area of action) above 2 m/s, preferably above 10 m/s, ideally greatly higher than 15m/s, in such a way as to bring to the area of effectiveness of the means of action or injector speeds above that of the water's natural movement, more specifically higher than 15 m/s and/or to achieve an action zone – perhaps in conjunction with one or more means of action or injectors – with a length of over 20cm, preferably more than 40cm, ideally more than 50cm, more specifically of at least the difference in levels between the level of the smallest wave trough and the highest wave peak.

The means of action or injectors are preferably placed along the side wall(s) of the pool so as to act in the areas of the pool where the waves trough and/or peak, the means of action or injectors being preferably positioned in groups separated from each other by a distance approximately equal to an integer multiple of one quarter of a wavelength, or even an integer multiple of one half of the wavelength of the desired or predetermined wave. In the event that certain vertical means of action or injectors act upon the antinodes (troughs – crests) and other horizontal ones act upon the nodes (no vertical displacement) the vertical means of action or injectors are placed such that their action is situated a quarter of a wavelength apart from the horizontal ones.

The means of action, or injectors could equally be arranged at the bottom of the pool, in an area or areas away from the edges of the pool where peaks and troughs are anticipated.

Ideally, each means of action or injector is adapted to achieve a maximum fluid output of less than 2l/s, preferably less than 1 l/s, ideally less than 0.5 l/s, more particularly less than 0.25 l/s. Preferably, the fluid output from the means of action or injector will be reduced, but said fluid will be ejected with considerable speed so as to generate a wave surge particularly in the action zone. Larger outputs are possible with larger means of action or injectors for example to agitate the liquid in a large volume pool.

More particularly, the means of action or injectors will be adapted to be used alone, or in conjunction with one or more others, to create an action zone at least on the crest or on the trough of a wave. The means of action or injectors will for example be adapted to ensure that the fluid reaches a height above that of the highest wave, or to reach a point lower than the lowest wave level, so as to increase the wave effect.

Preferably, the control system will inject the fluid by one or more means of action or injectors into an area of the pool as the liquid level in the area is in its ascent phase.

One or more means of action or injectors are preferably improved or linked to a specially built vortex system or Venturi system, creating, as does the simple injector, an intake of liquid from the pool and ejecting it to create a wave. The vortex or Venturi system can be fitted with one or more systems to control the quantity of liquid taken in or ejected from the vortex or Venturi.

In one form of embodiment, the system comprises a first series of means of action, namely injectors, and a second series of means of action, namely injectors, and the control mechanism controls the speed and/or pressure of the fluid from the means of action or injectors such that when the speed and/or pressure of the fluid output from

the means of action or injector is nil, or detectably nil, the speed and/or pressure of the fluid output from the means of action or injectors in the other series is maximal or detectably maximal. The means of action or injectors are linked in either a vortex shape, on rails, on linear or vertical slopes or curves, possibly inclined in relation to a horizontal surface, in a fan formation, etc

In a detail of an embodiment of the invention, the system comprises one or more substantially vertical series of means of action or injectors and one formed piece, adapted to the shape of a submerged edge of the pool. This formed piece preferably has a shape that guides the liquid in the pool away from the dead areas of the pool. Moreover, this formed piece can possibly contain an absorber or dissipater to dispel the jet of a means of action, or continuous injector, in its inactive phase

In one form of embodiment, the system comprises more than one series of means of action or injectors, each series of means of action or injectors being linked to a separate formed piece. Each series is for example situated in a corner of the pool. In particular, a series of means of action or injectors is situated substantially in each corner of the pool.

In a detail of another embodiment, the system comprises more than one series of means of action or injectors, for instance, two series of means of action, or injectors being linked to a first formed piece, whilst two other series of means of action or injectors are linked to a second formed piece. The formed pieces are for instance placed along the length of the shorter opposing walls of the pool. The formed pieces with distribution lines of means of action or injectors may be situated between said first and second sections, for instance in the vicinity of the bottom of the swimming pool or pool.

The system preferably comprises a means of creating a fluid that is pressurised and/or accelerated. Such means being for example a gas, air or vapour compressor,

a turbine, a liquid, water or carbonated water compressor, a liquid pump (centrifugal or volumetric), a pump submerged in the pool, or a combination of these methods. The method is therefore preferably chosen from the group comprising methods of putting gas under pressure, particularly air, vapour, hot air, methods of putting liquid under pressure, particularly water, methods for moving fluids at speed, particularly water. In certain possible applications (such as chemical processes, treatment processes, etc.) several additives or reagents or active agents may be added to the fluid (such as chemical reagents, bacteria, anti-bacterial agents, anti-fungal agents, anti-algae agents, etc.)

The system as per the invention preferably comprises one or more pumps submerged in the pool, or placed in technical zones, these pumps pumping liquid from the pool to propel it across one or more injectors, or using liquid external to the pool, possibly already under pressure.

In one form of embodiment, a control device controls the direction of the fluid emitting from the means of action or injectors and/or controls a component capable of being placed in the flux of the fluid output from the means of action, or injectors. In particular, the control device comprises:

- a submerged component presenting one surface with one or more window for the at least intermittent passage of fluid ejected from one or more of the means of action or injectors and
- a system inducing a relative movement between the output of one or more means of action or injectors and the window of the immersed component and/or controlling the relative movement between the window and a closing component adapted to seal, al least partially, said window.

In a preferred embodiment, the system is linked to one or more means of action or injectors so as to induce in the said injector(s) or at least in a number thereof, a rotational or pivotal movement, preferably in the form of a back-and-forth movement. For example the system induces a pivotal movement between –15° and + 15° relative to an upward-facing vertical rudder.

The invention also includes a pool that is destined to contain a liquid at the surface of which waves are created; said pool being associated with at least one system created using this invention. Such a pool might be for example a water treatment pool, a purification pool, a reaction chamber, or in particular, a swimming pool.

The object of the invention is equally to create waves at the surface of a liquid contained in a pool, in which

- fluid is injected into the liquid by various means of action or injectors and
- the functioning of the injectors is controlled in order that one or more means of action or injectors act so as to either amplify the trough of a wave, or to amplify the peak of a wave (or to amplify the horizontal movement of a wave).

In this procedure, a system used as outlined in this invention is advantageous.

The details and features of the invention will be outlined in the detailed description that follows, in which reference is made to the attached drawings.

<u>Brief description of the drawings</u>

In these drawings,

- figure 1 is a diagrammatic view of a swimming pool fitted with the system as per the invention;
- figure 2a is a diagrammatic view of a swimming pool showing two distribution lines with a series of injectors;
- figure 2b is a diagrammatic view of a swimming pool with four distribution lines with a series of injectors;
- figure 2c is a diagrammatic view of a swimming pool with a distribution line with five series of independently controlled injectors;
- figure 3 is a diagrammatic view of a system as per the invention;
- figure 4 is a diagrammatic view of another system as per the invention;

- figures 5a and 5d show the amplification of movement at the surface of the water;
- figure 6 is a view showing the direction of the jet emanating from the injectors;
- figure 7 shows a vortex used to increase efficiency;
- figures 8a and 8b show systems comprising a Venturi;
- figures 9a and 9b show a system acting intermittently on the flow of fluid ejecting from an injector;
- figures 10a and 10b show a system controlling the pivoting of the injector or the injector distribution line;
- figures 11a and 11b show a system acting on the injector outlet pipe; and
- figures 12a and 12b show a system show a system comprising a rotating distributor controlling the functioning of an injector;
- Figure 13 is an assembly of figures 1 and 10a, serving as an illustration for the abstract, and the contents are marked for reference.

Description of the preferred embodiments

Figure 1 shows a substantially parallelepipedal swimming pool 1 comprising a filtration system 2. This filtration system comprises a water reception tank 3 (filled by overflow when the water from the pool next to the water reception tank passes above a set limit, for example the system of pool overflow channels, or a system of skimmers or even by a door 4 whose vertical position can be set or controlled). The water passing into the tank is led to a pump P that propels water into a filtration device F and then into a channel 5 to take filtered water through an opening 6 situated in the bottom 7 of the pool or other locations on the bottom or in the walls. The pool can be in any shape whatsoever, the parallelepipedal shape serving merely as an illustration.

The pool is also equipped with a system for creating waves at the surface of the water in the pool. This system comprises a series of injectors 8 (three are shown, however the pool can for example be fitted with 20, 50 or even more injectors), each

injector 8 being itself, or specifically linked to, a vortex device 9 (see figure 7). The injectors 8 are linked by a pipe 10 to a pump PV, which is linked by a tube 11 to the channel 5, which is designed to take filtered water back into the pool. The pump PV is designed to take water that has been filtered and preferably supplemented with an agent (disinfectant, chlorine, biocide, fungicide, anti-algae, etc) coming from a reservoir 12 or present in filter F, into the injectors 8. The water is pressurised, possibly at variable times, in the pipe 10, this pressure varying for example between a minimum pressure of 0.2 bar (0.2 10^5 Pa) and a pressure of 20 bars (20 10^5 Pa). Pipe 10 may be equipped, with a valve 13a in the vicinity of the injectors 8 or a valve 13b in the technical location. Water output from the injectors 8 is ejected at a speed greater than 15m/s and with a rate of flow less than 0.5 l/second per injector (except for large injectors) for example less than 0.25 l/second. The speed of water ejected from the injector will be preferably chosen so that the injector's action zone ZA extends at least substantially to the vicinity of the surface of the liquid SL, the level of which can vary between a maximum level NM1 and a minimum level NM2. Injectors are preferably placed beneath the minimum water level, corresponding to the trough of a wave of maximum amplitude, while the speed of water ejected from the injectors is preferably chosen such that when the injector pushes a wave upwards, the jet of water ejecting from the injector is of sufficient speed to at least partially eject above the wave.

To regulate the speed of water ejected from the injectors 8, an electronic device 15 receives information from a sensor or detector 14 on the height of the wave for example in the zone situated above the injectors 8, or in an unperturbed zone whose phase difference is known. Once the sensor 14 (which measures for example pressure or acceleration on the peak of a wave, or surface movement – ultrasound, optical, etc) detects the crest or close to the crest of a wave, the electronic device controls the pump PV and/or the valves 13a or 13b to increase the water pressure in pipe 10 and to push the water out through the injectors 8 with sufficient force to multiply or increase the wave level or to increase the amplitude of the waves. As soon as the electronic device detects a movement towards the lower water level in

the zone situated above the injectors 8, the electronic device stops the pump PV functioning or closes a valve 13.

The link between the information from the sensor and the command could judiciously be treated as though occurring in a repetitive cycle, and therefore one could optimally speed up the triggering of the injectors such that their action begins de facto at the right moment without delay due to the triggering system.

Water output from the injectors is ejected at considerable speed (at the time of the operation to raise the wave) such that it causes the water adjacent to the injectors to be swept along and to push this mass of water (water ejecting from the injectors + water swept along by the water ejecting from the injectors) It has been noted that when using the injectors propelling a low output volume of water at high speed that the effect of the injector is substantially independent of the speed of the wave. The injector thus exerts a force on the liquid rather than necessarily displacing a considerable mass of this liquid. The injectors are therefore designed to transfer power.

The injectors 8 are placed in the vicinity of a side wall of the pool at a level situated below the minimum level NM2, for example at a level situated from 20 to 200cm below the minimum level NM2, for example between 30 and 100 cm. A formed piece 16 is linked to the injectors 8, this section 16 extending between the bottom of the pool and the wall along which the injectors are extended. This curve acts as a protection for the injectors 8, but also forms a guide for the water moving at the bottom level of the pool. Moreover, this formed piece could possibly contain an absorber or dissipater to distribute the jet of a continuous injector in its inactive phase.

The injectors are for example substantially monodirectional, for example with a dispersion angle between +15° and –15° (preferably between -10° and +10°; ideally

between -5° and +5°) from the central axis of the flow of water ejecting from the injector.
They should, if placed side by side, form a curtain, or when spread out across an area, a cone or a conical ellipse.

The pump PV is preferably equipped with a safety system 17, 18 such that, as soon as the pressure in the channel exceeds a safety value, valve 18 opens to permit a passage of water through channel 17 from the exit to the entrance of the pump.

The pump P, the filter F, the pump PV and the control device are preferably situated in the same service space.

Figure 2a shows a pool 1 similar to that shown in figure 1. This pool 1 is linked with two distribution rails 20,21 of injectors 8.These injectors 8 are placed in the vicinity of the bottom of the pool 22, along a lateral distribution line 23 (for example extending along the length of the pool LARG). The injectors 8 on distribution line 20 are attached in a pattern of three series of injectors, a first series 80 (for example of at least 5, preferably at least 10 injectors, for example 20, 30, 50 injectors) situated in the vicinity of the first corner 24 a second series 81 (for example of at least 5, preferably at least 10 injectors, for example 20, 30, 50 injectors) situated in another corner 25 and of at least a series 82 of injectors (preferably comprising a larger number of injectors than the number of injectors in a corner, for example twice, or more than twice, the number of injectors in a corner series), said series 82 being situated in relation to a series of injectors in a corner at a distance equal to a whole multiple of a wavelength LO of a wave formed in the pool. In the form shown (where one single series 82 is placed between series 80 and 81) series 82 is situated at a mid point between series 80 and 81.
The injectors 8 on distribution line 21 are affixed in the form of a series of injectors 83, 84 comprising preferably a larger number of injectors than the number of injectors in a corner, for example twice or more times the number of injectors than the number of injectors in a corner series. Each series 83, 84 is situated between

two series (80, 81, 82) of injectors 8 on the first distribution line 20. For example each series 83, 84 is situated at a mid point between the two series (80, 82; 82, 81) of injectors on the first distribution line 20.

The injectors 8 are protected by a formed piece 16.

Distribution lines 20, 21 are link to a source of pressurised fluid (P1, P2) and a control mechanism 15 controlling valves 90, 93 by means of one or more pressure sensors 100, 101, 102, 103, 104. For example, each sensor detects a wave state in the area situated above a series of injectors. This allows the functioning of each series to be controlled independently of the others as a function of the state (level) of the wave in the area situated above the relevant series of injectors.
Equally, a centralised control is possible.
The sensors could equally be level, sound, optical or acceleration types.
The control device receives information from the sensors 100, 101, 102, 103 and 104 via a cable 30 or a RF transmission system, sonar, IR optic, with or without fibre optic cable, and sends instructions to valves 90, 93 by a cable 31, and by means of an electronic control system.

Preferably this same fluid is injected by injectors 8 on the distribution line 20 and by the injectors on distribution line 21. Nevertheless in a possible embodiment of the invention, distribution line 20 allows the injection of a first fluid (water) whereas the other distribution line allows the injection of a second fluid, different from the first (for example, a gas, air, oxygen, carbonated gas, water with different properties to that used in distribution line 20, etc.)
In one form of embodiment, the same distribution line can also simultaneously inject two elements of air and water.

Figure 2b is a view of a pool similar to that shown in figure 2a., except that it comprises four distribution lines 20, 20bis, 21, 21bis of injectors, the injectors 8 of a first pair of distribution lines 20, 21 being situated in the vicinity of a first side wall 23

of the pool, whereas the injectors 8 on the other two distribution lines 20bis 21bis are situated in the vicinity of another wall, preferably wall 23bis opposite wall 23.

Figure 2c is a view of a pool comprising a distribution line 20 with five series of injectors 80, 81, 82, 83, 84 each linked to the distribution line 20 by an individual valve 70, 71, 72, 73, 74. Each valve comprises or is linked to a control system and/or controller (such as a micro controller, a micro mechanism, a microprocessor, a float, a flue valve float, a valve float) receiving an indication of the liquid level in a given area.

Figure 3 is a view of a particular embodiment for a device to inject water into the corner of a pool. The device comprises a formed piece 16 that extends between the bottom 22 of the pool and the two lateral walls (23, 23ter). The water from the pool is able to pass under the section 16 through the openings 27. A submerged pump 32 functioning with a low voltage electricity supply (for example, 12 volts, 24 volts, 36 volts) is placed below the section 16. The electricity supply to pump 32 is provided by means of a cable 33 linked to a source of electricity and a control device 15 and passing through opening 6.

The pump 32 thus pumps water from the pool and forces this water through a head 34 presenting a series of openings 35 such that a group of water jets are created with low output but at high speed. The jets moving from head 34 form water pressure PE presenting a central axis (preferably vertical or substantially vertical) 36. The alpha angle of the opening of the series of jets 37 emanating from the head is between 5 and 10°. The jet speed is chosen so that the action zone ZA of the jets is extended beyond the maximum wave level, when there is the possibility of increasing the movement or amplitude of the movement of the wave. The water is thus forced or driven above the maximum wave level, forming a sort of miniature fountain or spurting water source. The jets thus preferably form a current of water coming out of the wave at a height H of at least 1cm for example between 5 and 20cm, perhaps more, but ideally less than 10cm. These jets of water spurting from

the pool allow, as well as amplification of the waves, oxygenation of the pool, circulation of the water, the formation of mini waves V1 moving on the waves V.

Figure 4 is a view of another form of embodiment. In this form of embodiment, the injectors 8 are situated above the average pool level N, or in the vicinity of this level. The injectors 8 are arranged so as to push the water towards the bottom 22 of the pool. In this form of embodiment, water is ejected from the injectors at high speed when the sensor detects a wave trough, or a detectable wave trough. In this embodiment of the invention, the injectors 8 are situated beneath the plank 40 of the diving board, or the starting block.

Figures 5a and 5d show the levels for the formation of waves in a type of pool shown in figure 2b.

The injectors on the distribution line 20 are activated to create an initial swell above the injectors 8 on the distribution line 20. A first wave is thus created. The injectors 8 on distribution line 20 are deactivated as soon as the sensor 100 detects that the wave in the zone situated above the distribution line 20 moves away from the crest of the wave (descending wave movement). (figure 5a)

The wave is thus propagated towards wall 23bis. As soon as the sensor 101 detects a state corresponding to a wave swell movement detectably reaching a peak, the injectors 8 on distribution line 20bis are activated to push towards the peak of the wave. The injectors 8 on distribution line 20bis are deactivated as soon as the sensor 101 detects that the wave in the zone situated above the distribution line 20bis moves away from the crest of the wave (descending wave movement). (figure 5b)

Similarly, as soon as the sensor 100 detects a state corresponding to a detectable wave swell movement reaching a peak, the injectors 8 on distribution line 20 are activated to push towards the peak of the wave. The injectors 8 on distribution line

20 are deactivated as soon as the sensor 100 detects that the wave in the zone situated above the distribution line 20 is moving away from the crest of the wave (descending wave movement). (figure 5c)

The amplitude of the wave is thus amplified (figure 5d).

Figure 6 shows possible locations for the injectors. Thus in the form of embodiment shown in figure 6, the corners of the pool are fitted with a series of vertical injectors inducing, when activated, an upward surge PV, a series of horizontal injectors parallel to one wall and adjacent to this wall, these horizontal injectors inducing a horizontal surge PH1 towards the corner of the pool, and another series of horizontal injectors parallel to another wall and adjacent to this other wall, these horizontal injectors inducing a horizontal surge PH2 substantially perpendicular to the surge PH1. The injectors in one corner are activated at the same time as the sensor detects a level corresponding detectably to a wave trough or a reflux wave movement. The combined use of vertical and horizontal injectors whose area of action reaches the action zone ZA of another series of horizontal injectors, or of vertical injectors, permits an increase in the speed at which large amplitude waves are formed. The injectors are deactivated just before the peak of the wave forms, and preferably reactivated just before the trough of the wave.

Figure 7 is a schematic diagram of a device for increasing the efficiency of the surge. In the embodiment shown in figure 7 the pressurised water enters a chamber 50 via the pipe 51. This water then passes along a substantially ring-shaped distributor channel 51B before passing into the injector ring 51A. This water carries the water entering through the lower part of chamber 52 to exit towards the upper part of the chamber.

In figures 8a and 8b a Venturi 55 allows a central (8a) or lateral (8b) intake of water. In the form illustrated, it is anticipated that there will be an intake of air into the Venturi, this intake is achieved through conduit 56. The air intake is for example

obtained by the depression created by the high-speed jet ejected from the injector 8. The air may also come from a source of compressed air, this air being introduced into the Venturi in a continuous or non-continuous manner, preferably in a continuous or substantially continuous manner, and ideally in a manner proportional to the water output, and for example in a sinusoidal or sine-type manner in the same manner as the jet of water. This addition of compressed air even allows the amplitude of the wave movement to be further amplified.

In the embodiment shown in figure 9a, the pool includes a distribution line 20 of injectors 8, this distribution line 20 being situated below the formed piece 16 adjacent to a lower side of the pool. The formed piece 16 presents a series of openings 200 each positioned above an injector output. A curved piece, or arm 201 is jointed to a shaft 202 and is connected to a control device 203 controlling a pivotal back-and-forth movement. This control device comprises, in the form illustrated, a cylinder 203A, whose rod 203B acts on the formed piece 201. The cylinder is pivotally fixed to the vertical wall of the swimming pool, whereas the rod 203B is pivotally connected to the formed piece 201. This formed piece 201 is adapted so that a part of the formed piece or the interdependent closing sections of the formed piece moves between a position in which the formed piece or the interdependent closing sections close the openings 200 so as to prevent the fluid output from the injectors passing through the openings 200 (the flow of the fluid is then guided into chamber 204 situated under the formed piece 16), and a position for which the flow of fluid ejected from the injectors passes through the openings 200 so as to create movement on the surface of the pool. In this form of embodiment, the flow and the pressure of the fluid ejected from the injectors are preferably constant. It is the movement of the formed piece 201 that either acts upon a wave (water passing through the windows) or does not act upon a wave. Rather than use a cylinder, one might be able to use another mechanical device, such as an electro-magnetic system, a crankshaft, an alternating motor or geared motor, etc.

Figure 9a shows the position of the formed piece 201 not closing the openings 200, whereas figure 9b shows the position of the formed piece 201 closing the openings.

Figure 10a shows a form of embodiment similar to that in figure 9a, except that the injector 8 or the distribution line 20 is mounted pivotally on a shaft 210. A device controls the pivoting of the injector or of the formed piece such that the output from the injector 8 is directed either towards the opening 200 of the formed piece 16, or onto a closed section of the formed piece 16. In figure 10a, the injector 8 is directed such that its outflow passes through the opening 200 and acts upon the waves. in figure 10b the injector 8 is directed such that the outflow runs up against the wall of the formed piece 16.

Figure 11a shows a form of embodiment similar to that in figure 10a, except that the injector 8 is connected to a flexible tube 211, which is connected to a cylinder 203A from which the rod 203B is connected via a support 212. In figure 11a, the tube 211 is placed such that its outflow passes through the opening 200 and acts upon the waves. In figure 11b, the end of tube 211 is placed or adapted such that the outflow runs up against the wall of the formed piece 16.

In figure 12a, the form of embodiment comprises a distribution line 20 with injectors 8. A hollow distributor cylinder 213 presents a series of openings 214 arranged in a regular manner (for example every 120°). The distribution line 20 is placed in the hollow 215 of the distributor cylinder 213. A motor (not shown) turns the distributor cylinder 213 such that the fluid output from the injectors passes for a period of time through the windows 214, and for another period of time flows against an interior wall of the cylinder distributor 213 (wall situated between two openings 214). The distributor cylinder 213 is preferably mounted on bearings supported by the opposite wall of the pool. By controlling the rotation speed of the distributor cylinder 216 the times during which the injectors have an action upon the wave can be controlled.

It is possible to make numerous modifications to the forms of embodiment shown in these figures.

The injectors, instead of injecting water, could inject another fluid such as gas, for example air, oxygen, nitrogen, oxygen-enriched air, etc or a mix of these, this other fluid being injected in combination or not with a liquid.

In the system as per the invention, the operation of the injectors must be controlled. The injectors' are preferably synchronised in terms of both frequency and relative phase. This synchronisation is achieved by sensors and an electronic device or control mechanism. In the event that an electronic system is used, the system may include means of controlling the injectors allowing a rapid transition from one type of wave (wave length, amplitude, frequency of waves, etc.) to another type of wave. In this instance the injectors possibly function when the sensor detects a wave trough, or an upward wave movement towards in a given area.

The injectors are specifically arranged along a wall, in particular along a lateral (or longitudinal) wall, preferably in the vicinity of the bottom of the pool in the case of vertical injectors. Some or all of the injectors may also be situated in other places, for example at the centre of the bottom of the pool, between the walls, in a chamber adjacent to the pool, in a chamber created within the pool. The injectors, or some injectors, can be placed at a distance from the edge or transversally to an edge, for example at the point of the antinode of the wave to be formed. Placed at the bottom, or close to the bottom (preferably combined with a protective cover) the injector does not disturb the circulation in the pool or its use. The exact position of the injectors for a given tank or swimming pool may be obtained by an experimental study or by physical simulation models.

The injectors or series of injectors are in phase, or in counter-phase, or with a set phase difference (for example 90°) preferably controlled according to the surface state.

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The more widely the injectors are distributed in different areas of the tank or swimming pool, the better the wave types will be, but the possibility of stimulating different modes once the mode of wave is obtained is reduced.

To reduce the amount of pipe work the injectors are preferably placed in the vicinity of the water overflow tank for filtration.

The injectors can be of alternating types, i.e. permitting at one point a surge from the bottom to the top, and at another from the top to the bottom, or permitting at one point a surge to the left and at another a surge to the right. It is equally possible to combine the injectors functioning in opposing directions, or substantially opposing directions. In the case of injectors with vertical action in the opposing direction, it may prove effective to place the injectors or an injector with alternative action in an area at a corresponding height to that of the amplitude of the wave, such that the injector is below the level of the wave when a surge from the bottom towards the top and above the level of the wave when there is a surge from top to bottom.

The injectors can be put in place when the swimming pool is constructed, the pipes carrying pressurised fluid being then built-in or embedded. In one form of embodiment, the swimming pool is equipped with a series of openings in the walls, these openings being a covered end of a pipe that is to be linked to a water supply system. The ends of these pipes are then closed with a cover or a cap, when the swimming pool is not fitted with injectors. In one form of embodiment, the openings are preferably equipped with a system to gauge a state of the liquid surface of the pool, or with a connection to send a parameter of the liquid surface state of the pool to a control device.

The injector can be vertical or can be at a slight incline to the vertical, for example forming an angle between -30° and +30°, preferably between -10° and +10°, more particularly between -5° and +5°. The vertical injector directs its jet preferably along

the vertical wall of the pool. The injectors can be of a fixed type (predetermined position) or mobile (the direction of the jet can vary in a determined directional field), even controlled (the direction of the jet can be controlled according to the state of the wave). Control of the direction of the jet could be programmed by an electronic system (for example the system which controls the functioning of the injectors). For this control, the injectors are mounted as mobile fixtures in relation to a support, for example mounted rotationally in relation to an axis, rotation being controlled by a motor, a hydraulic or pneumatic system, etc.

The direction of the injector jets can be modified by the movement of the liquid or according to the movement of liquid or according to the parameter of the wave (frequency, wave length, etc.) In one form of embodiment, the jet movement or at the very least a part of the movement thereof would be generated by the natural movement of the liquid in the tank or swimming pool. This directional jet control would thus permit the movement of a wave to be amplified whilst taking into account the natural movement of the wave. The jet would in some way follow the natural movement of the wave. In one form of embodiment, the jet is assembled rotationally or pivotally in relation to a wall of the tank or swimming pool. The rotational movement of the jet, in particular for jets having at least substantially vertical component over the course of time, can be operated by means or a motor and controlled according to the water or liquid level in the vicinity of the jet, even perhaps carried directly along by the movement of the liquid itself.

To avoid or limit waves in an area of the pool, it is possible to plan for intermediary walls in the pool, or at least at the surface of the pool.

These intermediary walls could themselves be an opportunity to position injectors with their profiles and systems integrated.

The sensors allow movements of water in the pool and in the injectors to be measured (and thus thereafter to be controlled). These are for example:

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- absolute or differential pressure sensors
  - which measure pressure at different locations in the pool and more particularly:
    - near the areas where the injectors act
    - in areas affected by the injectors
    - in the area of the injector output
    - in areas where variations are to be created or avoided
    - in areas situated at multiples of half wave lengths
  - which measure pressure in the injector piping
    - at pump exits
    - before and after valves
    - before injection
- water presence sensors working by capacitative, optical or other means, allowing the measurement of variations, periods and phases of water levels.
- ultrasound sensors, either submerged or out of the water that measure the distances between one reference and the surface of the water.
- and all other types of sensors judicious to this application

The fluid supply, water in particular, in the injectors is preferably controlled by means of one or more pump/s and/or valves

The pressure supply will generally be a pump. However, one might envisage, in particular when wave duration is relatively brief, using energy from water under pressure available elsewhere. This may prove advantageous in certain applications where a water supply is required in any case.

This source of pressure could be modulated, either by varying the speed of the pump motor, or by working with a permanent pump and acting upon a valve that regulates the fluid input into the injectors.

The system that varies the motor speed will use electronics appropriate to the motor type, for example using a frequency variator or voltage variator or any other electro-mechanical system. It is to be noted that it is not necessary to completely stop the pump and that, on the contrary, for good efficiency one should always keep the motor at a minimum speed, only varying the speed within a certain range.
(for example by supplying it with between 20 and 50 Hz for a power pump working at a nominal 50 Hz at a nominal speed of 1450 revolutions per minute)

The velocity curve imposed on the pump will for example take into account the characteristics of the pump, the need for variable power at the optimal area of the liquid, the performance of the injectors and the loss of hydraulic circuit function. Good results may for example be obtained with sinusoidal curves whose offsets and curves are judiciously chosen. Valid results are equally obtained with a square, symmetrical or asymmetrical commands.

The system working with valves could for example use:

- Proportional valves
- ON-OFF valves
- Multi-channel or distributor valves
- Rotary valves with output adjusted according to position

Proportional valves allow precise and adjustable injection control.
They do not however offer optimal efficiency as over time a part of the energy is lost, especially if several valves are used and if they output alternately from different injectors, the sum of the outputs being more or less constant.

ON-OFF valves are more straightforward, the required effect is good, but the structure of the wave will be less pure as interference waves are generated. This fault may be corrected with the addition of additional valves, with well-chosen output and thus one can work with ON-OFF valves (as in binary) almost in proportional mode.

Multi-channel valves easily resolve the problem of symmetrical and alternate transmission in two series of injectors placed at opposite phase positions. They are, depending on their construction, either proportional or ON-OFF

One can also have a series of off-phased injectors at an angle different to 180° and therefore the valves redistributing the flow in multiple ways within the 360° of a period.
One might even envisage periods of longer than 360° and taking into account the frequency of beats inside the mixing reservoir.

Rotary valves with outflow adjusted according to their position allow water to be sent in a simple and optimal mechanical way (once everything has been calculated, adjusted, tested, etc.) in a cyclical fashion (in the desired wave rhythm) into the different injector circuits. A pump working continuously and therefore with optimal productivity sends water via this rotary valve into different circuits, and they receive the water they require at exactly the right moment and with exactly the right curve (for example pure sinusoidal, sinusoidal with gain and offset, square wave, etc).

These rotary valves are multi-channel valves that distribute the output to one, two or more openings, in a repetitive fashion as a function of their rotating speed. They can be ball, cylinder or cone valves, like plug valves. As the valves may be submerged minor leakage is not a problem, and they can therefore turn permanently with practically no friction and therefore no wear.

With the valves, as with the variable speed of the motors, one should not necessarily completely cut the inlet into the injectors. In fact an injector which only receives perhaps a few tenths of a percent of its nominal flow produces practically no power, whereas to switch the entire stream of water back on from a flow of zero would require more time and power.

Regulating the frequency, phase and amplitude of the wave would best be controlled electronically.

Wave generation using these injectors, pumps, valves and sensors borrows much from the WOW ® wave ball commercialised by the applicant, in the knowledge that the use of the concept of an injector, which is in some ways an output-multiplier/pressure divider, allows the "fixed" injection point to be rendered relatively undetectable to the relative speed of the water. In fact, the speed at which water is output from the injector is an order of magnitude higher than the fastest water flow in the area of the effective surge after the multiplication effect.

In the system as per the invention, advantage can be taken of the wave resonance effect, as well as all the regulation and the optical, sonic pressure (etc) sensors that can monitor wave movements as well as the injector commands and the result of the injectors.

One could even envisage measuring the pressure of the liquid in the injector area, by measuring of the counter pressure of the injector itself.

The system as per the invention also offers potentially beneficial side effects: massages, bubbles, aeration, oxygenation, degassing of a liquid medium, etc.

The injectors can also be placed in carefully selected areas away from the edges, for example in the middle of the pool or close to the antinode of waves, at the point where bathers can, in addition to the waves, benefit from the effects of jets and bubbles.

The starting blocks (diving boards) for public pools can easily become wave generators with power injectors from above without any interaction with the pool reservoir (except for the water supply, which can be via the filtration circuit).

Integrated filtration blocks can serve as wave generators and can also include the bubble and diving board aspects.

It is clear that one or more of the injectors or a series of injectors can be used to create one or more fountains or jets of liquid, which rise at least partially above the surface of the liquid.

It is equally clear that the pool can be a pool with one or more lateral walls, defining a closed or substantially closed volume.